Journal of Infection and Public Health (2016) 9, 571—576

http://www.elsevier.com/locate/jiph

Prevalence of methicillin resistant *Staphylococcus aureus* [MRSA] colonization or carriage among health-care workers

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Received 4 August 2015; received in revised form 14 November 2015; accepted 11 December 2015

KEYWORDS
Staphylococcus aureus;
HA-MRSA;
Prevalence;
Nasal;
Oxacillin;
Methicillin

Summary In Oman, the prevalence of health care associated methicillin resistant *Staphylococcus aureus* [HA-MRSA] is unknown. Therefore, to estimate the prevalence of HA-MRSA, we collected nasal swabs and swabs from cell phones on sterile polyester swabs and immediately inoculated on the mannitol salt agar containing oxacillin from medical students and hospital health care providers. Antibiotic susceptibility testing of the isolates was then performed using the Kirby Bauer's disc diffusion method. Additionally, a brief survey questionnaire was used to acquire demographic data. Amongst the 311 participants enrolled, nasal colonization with HA-MRSA was found in 47 individuals (15.1%, 95% confidence interval [CI] = 11.1%, 19.1%). HA-MRSA was also isolated from the cell phone surfaces in 28 participants (9.0%, 95% CI = 8.6%, 9.3%). 5 participants (1.6%) showed positive results both from their nasal swabs and from their cell phones. Antibiotic resistance to erythromycin [48%] and clindamycin [29%] was relatively high. 9.3% HA-MRSA isolates were vancomycin resistant [6.6% nasal carriage]. There was no statistically significant correlation between HA-MRSA isolates and the demographic characteristics or the risk factors namely gender, underlying co-morbidities like diabetes, hypertension, skin/soft tissue infections, skin ulcers/wounds, recent exposure to antibiotics, or hospital visits ($p > 0.05$, Chi-square test).

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http://dx.doi.org/10.1016/j.jiph.2015.12.004

Introduction

Staphylococcus aureus remains a common cause of infection in the community for centuries. In the last few decades, methicillin-resistant *Staphylococcus aureus* (MRSA) has become an increasingly important cause of healthcare-associated infections [1—6]. Moreover, these staphylococci that have become resistant to beta-lactam antibiotics can occur in healthy persons without traditional MRSA associated risk factors [7]. Furthermore, since 1990s, MRSA has also emerged as cause of infection in the community [8,9]. Although literature review indicates that there is considerable variation, nasal carriage of MRSA is reported to vary between 6.3 and 17.8% in the general population and between 18.2 and 43.8% in health care workers [1—6]. Nevertheless, transmission from person to person and from health care worker to patients is a primary health care concern.

The prevalence of health-care associated MRSA (HA-MRSA) is higher than health-care associated methicillin-susceptible *S. aureus* in some countries [10]. While MRSA infections are associated with increased mortality and costs for the healthcare systems in developed countries [11], the impact can be worse in the developing countries. The spread of HA-MRSA in resource-limited settings can have devastating consequences because of the lack of microbiology laboratories with outbreak investigation capability and inadequate facilities for bacterial identification and antimicrobial susceptibility testing as well as the high cost of antibiotic drugs required to treat severe HA-MRSA infections [12].

The prevalence of MRSA varies from hospital to hospital in various countries and is constantly rising in many countries raising public health concerns. In many American and European hospitals, the percentage of MRSA has ranged from 29% to 35% [13,14]. The incidence of MRSA in developing countries like India ranges from 30% to 70% [15,16]. HA-MRSA strains continue to be a major problem in many institutions, and they now account for more than 50% of *S. aureus* recovered from patients in intensive care units (ICUs) and about 40% of the *S. aureus* isolated from non-ICU patients [13—17].

Unfortunately, the prevalence of MRSA in Oman is unknown. It is therefore important to estimate the prevalence of HA-MRSA in Oman. Thus, in view of the rising trend of increasing prevalence in HA-MRSA, and its propensity to spread to the community, we initiated this study to screen for HA-MRSA by nasal as well as cell phone swabs because it will give an added perspective to the Omani health initiative. Cell phone is perhaps the most extensively used device today, which due to inadvertent negligence, may unknowing allow the transfer of microorganisms from person to person/inanimate surroundings. Furthermore, this study also encouraged participants to fill a brief survey questionnaire to record their age, gender, history of infections if any, frequency of hospital visits and location of residence, etc. as well as associated co-morbid conditions like diabetes and hypertension or recent skin/wound infections in an attempt to understand risk factors that could be significantly associated with the high prevalence.

Materials and methods

Study design and subjects

The study design was a prospective cross-sectional cohort study which was approved by the institutional research and ethics committee. Participants were enrolled after a written informed consent. The health care workers enrolled in the study were pre-medical students at the Oman medical college [Bowsher campus-Group A], clinical year medical students with hospital exposure [Sohar hospital-Group B], and various hospital health care centers and private health clinics in Muscat [Group C]. Nasal and cell phones swabs from all participants were directly plated into a selective mannitol salt agar with oxacillin that would allow growth of only methicillin resistant microorganisms.

Demographic data was also collected which included age, gender, wilayat, and nationality, hospital exposure, hand washing habits, bathing habits and sharing of personal belongings, recent exposure to antibiotics, co-morbidities, and skin wounds. This data was recorded to assess any possible risk for MRSA carriage.

Sample collection and transportation

Samples were collected from both anterior nares using sterile polyester swabs with a standard rotating technique. Similarly, the surface of participant's personal cell phones were also swabbed using swabs pre-moistened with sterile saline [18]. Landers et al. [18] observed that of the five swabs dry, premoistioned with or without pre-enrichment, the pre-moistened or pre-enriched swabs gave the best results. Hence we adopted the pre-moistening technique which is a simple and cost effective technique. These swabs were used for inoculation onto the mannitol salt agar containing oxacillin with minimum time lapse. Colony characteristics on the culture plates and Gram-staining were used to further confirm the identity of *S. aureus* that

Table 1a Demographic characteristics of the health care provider cohorts.

Characteristics	Number
Total subjects, *n*	311
Male/female	54/257
Mean age + SD, years	26.36 + 9.07
Median age, years	23
Range, years	17—62
A — Pre-clinical medical students [Bowsher], *n*	123
Male/female	8/115
Mean age + SD, years	20.18 + 1.18
Median age, years	20
Range, years	17—24
B — Clinical year medical student [Sohar], *n*	72
Male/female	8/64
Mean age + SD, years	22.97 + 1.69
Median age, years	23
Range, years	20—27
C — Hospital health-care worker cohort, *n*	116
Male/female	38/78
Mean age + SD, years	33.23 + 8.9
Median age, years	30
Range, years	22—62

grew on this MRSA selective medium. Salt tolerance and mannitol fermentation properties of *S. aureus* result in the typical yellow colonies due to a change in the pH. Gram staining helped to ascertain that there were no other airborne contaminants by confirming the characteristic morphology of *S. aureus*. Growth of any other microorganisms were noted but excluded from any analysis.

Antibiotic susceptibility tests were performed on Mueller-Hinton agar using Kirby Bauer's disk diffusion method [19] according to the Clinical and Laboratory Standards Institute guidelines. *S. aureus* ATCC 25923 was used as a control strain. The following antibiotics were used: erythromycin (15 μg), clindamycin (2 μg), rifampicin (2 μg), doxycycline (30 μg), vancomycin (30 μg), linezolid (30 μg) and teicoplanin (30 μg).

Statistical analysis

All the data was analyzed using IBM-SPSS ver 19.0. The prevalence of MRSA was estimated with 95% confidence intervals. Continuous variable are reported as mean ± SD with 95% confidence intervals. The correlation between categorical variables was determined by Chi-Square test for significance. Statistical significance was identified as $p < 0.05$.

Results

A total of 311 participants were enrolled in this study, with a mean age of 26.36 ± 9.07 years old; with most subjects being female (82.6%). The female predominance was reflected especially in the two medical student cohorts, but otherwise females comprised of only 35% in the hospital health worker cohort (Table 1).

Overall, HA-MRSA carriage was seen in 47 individuals in their nasal vestibules giving a colonization rate of 15.1% (95% CI = 11.1%—19.1%) (Table 2). HA-MRSA was also isolated from the cell phone surfaces in 28 participants yielding a carriage rate of 9.0% (95% CI = 8.6%—9.3%). In 5 participants (1.6%) HA-MRSA was isolated both from nasal vestibules and from their cell phone swabs. The rates in the nasal and cell phone HA-MRSA carriage were similar in the two medical student cohorts [Groups A & B] but the cell phone carriage in the hospital staff was significantly low [$p < 0.05$, Chi square test] compared to the two student groups.

Table 1b Underlying risk factors of the health care provider cohorts.

		Medical students (A and B)	Hospital health care workers (C)
Co-morbidities, %			
Diabetes mellitus		0	6.5[a]
Hypertension		0	6.5[a]
Ulcers		1	0[a]
Skin/soft tissue infections		5.6	0.8[a]
H/O recent exposure to antibiotics%	Yes	19.8	24.4[a]
	No	80.2	75.6[a]
H/o recent exposure/hospitalization	Yes	4.1	3.3[a]
	No	95.9	96.7[a]
Presence of wounds/skin lesions	Yes	2.5	0.8[a]
	No	97.5	99.2[a]

[a] NS, $p > 0.05$, Chi Square test.

Table 2 Overall prevalence of HA-MRSA in the health care providers as well as in the three study cohorts.

Cohorts→		Overall health care providers $N = 311$	Pre-clinical medical students [A] $N = 123$	Clinical year medical students [B] $N = 72$	Hospital health-care workers [C] $N = 116$
Nasal	N [prevalence (%)]	47 [15.1]	14 [11.4]	15 [20.8]	16 [13.8]
	95% CI range	11.1–19.1	5.76–16.99	11.44–30.2	7.5–20.06
p value			NS	NS	NS
Cell phone	N [prevalence (%)]	28 [9.0]	12 [9.8]	11 [15.3]	3 [2.6]
	95% CI range	8.6–9.3	8.1–19.0	6.97–23.59	1.7–4.54
p value			<0.03[a]	<0.003[b]	

CI — confidence interval; Chi square test — NS, $p > 0.05$;
[a] A v/s C;
[b] B v/s C.

A total of 75 isolates were obtained and confirmed as HA-MRSA from the culture characteristics and Gram staining. Antibiotic resistance with erythromycin and clindamycin varied between 29% and 48%, whereas, most HA-MRSA isolates were generally sensitive to rifampicin, doxycyline, vancomycin, linezolid and teicoplanin (Table 3). Furthermore, there was no significant differences in the resistance pattern between the nasal and cell phone HA-MRSA isolates [Table 3; $p > 0.05$, Chi square test] Overall, the vancomycin resistant HA-MRSA was 9.3% [6.6% nasal carriage].

There was no statistically significant correlation between HA-MRSA nasal carriage and the demographic characteristics or the risk factors namely gender, underlying co-morbidities like diabetes, hypertension, skin/soft tissue infections, skin ulcers/wounds, recent exposure to antibiotics, or hospital visits, etc. ($p > 0.05$, Chi-square test).

Discussion

In Oman, the prevalence of MRSA colonization or nasal carriage among health-care workers is unknown. This study showed that the overall prevalence of HA-MRSA nasal carriage in health care workers/students was 15.1%. Our health care worker cohort comprising of three sub-cohorts; a premedical student cohort with no hospital environmental exposure [Group A], a cohort of clinical year students with hospital environmental exposure [Group B] and a cohort of hospital health care providers [Group C] respectively showed HA-MRSA nasal carriage of 13.0%, 20.8% and 13.8% [Table 2; $p > 0.05$, Chi square test]. These results indicate that although the exposure of hospital environment led to a substantial increase of the HA-MRSA nasal carriage in the group B, it did not reach statistical significance, probably owing to the relatively small sample sizes.

A Thai study from Srinakharinwirot University in 2013 demonstrated that 29.7% of healthy, third-year, preclinical medical students carried *S. aureus*, but there was no MRSA carriage [6]. Another Thai study by Kitti et al., in 2011 reported that although there was 15% prevalence for *S. aureus*, they found only 1% MRSA nasal carriage in healthy young Thai adults [3]. In contrast, our current study shows a significantly higher percentage of nasal carriage of HA-MRSA. However, our results are similar to the Chinese study conducted in 2011 on a population

Table 3 Antibiotic resistance and sensitivity pattern of the HA-MRSA isolates [$n = 75$] in the three study cohorts.

Antibiotics	N[A#]	N[B#]	N[C#]	N, total	CP[A#]	CP[B#]	CP[C#]	CP, total	S[†] [%]
Erythromycin	7 [33]	4 [19]	10 [48]	21[**]	8 [53]	5 [33]	2 [14]	15	39 [52]
Clindamycin	5 [33]	3 [20]	7 [47]	15[**]	2 [29]	4 [57]	1 [14]	7	53 [71]
Rifampicin	0	0	1 [100]	1[**]	0	0	0	0	74 [99]
Doxycycline	2[50]	0	2 [50]	4[**]	0	1[100]	0	1	70 [93]
Vancomycin	2 [40]	0	3 [60]	5[**]	1 [50]	1 [50]	0	2	68 [91]
Linezolid	0	0	0	0[**]	1 [50]	1 [50]	0	2	73 [97]
Teicoplanin	3 [43]	0	4 [57]	7[**]	2 [67]	1 [33]	0	3	65 [87]

N — nasal swab isolates; CP — cell phone swab isolates; # — number [%] of resistant MRSA isolates; S[†]% — number [%] of sensitive MRSA isolates, A — pre-clinical medical students; B — clinical year medical students; C — hospital health care workers;
[**] $p > 0.05$, N v/s CP, Chi square test.

of preclinical medical students which reported a prevalence of 9.4% for MRSA nasal carriage [20].

In contrast, the prevalence cell phone carriage of HA-MRSA was almost half of the nasal carriage at 9.0% in our study. Here also we see the same trend for HA-MRSA cell phone carriage of 11.4%, 15.3% and 2.6% respectively in Groups A—C. [Table 2; $p < 0.05$, Chi square test]. Lower cell phones carriage of HA-MRSA was especially significant in the hospital setting. This is definitely a good indication. However it also emphasizes the need to reinforce an awareness campaign in the health care providers, especially medical students Groups A and B so that not only the health care workers but also students and hospital visitors take adequate care and precautions regarding the universal techniques of hand washing and hygiene. Thus contaminations of inanimate objects like cell phones will be further reduced and minimize the risk of transmitting HA-MRSA.

Antimicrobial resistance in *S. aureus* has become an increasingly widespread problem [7,10—14,21]. The antimicrobial susceptibility profile of *S. aureus* has been different in several previous reports and depended on the resistance profiles in the health-care worker groups [3—5,8,21,22]. In this study, antibiotic susceptibility tests revealed that the HA-MRSA isolates remained sensitive to most antibiotics, but there was a high rate of resistance against erythromycin [48%] and clindamycin [29%]. Although the clindamycin resistant HA-MRSA isolates obtained from nasal carriage [15] were twice as much as from cell phones [7], the resistance pattern was different with preponderance amongst the medical student groups A & B. Furthermore, as the sample size is small, this difference is pertinent and could be of clinical relevance. Most of the HA-MRSA isolates were sensitive to rifampicin [99%], doxycyline [93%], vancomycin [91%] and linezolid [97%]. Only one strain of HA-MRSA showed resistance to rifampicin and was isolated from nasal swab in a health care worker. Amongst the cell phone MRSA isolates none showed resistance in the health care workers [Table 3], whereas variable resistance was seen in the MRSA isolates from the medical students A and B. Interestingly, it was seen that only in the two medical student cohorts we could get five cases wherein nasal as well as cell phone MRSA carriage was found in the same individual. Thus, the overall relatively higher prevalence of resistant HA-MRSA isolates amongst the medical student groups A and B points to the need of highlighting the universal techniques of hand washing and hygiene in these students of the two cohorts. Significantly, the study did not find any multi-drug resistant HA-MRSA isolates.

Several risk factors are generally associated with HA-MRSA isolates [23]. In this study we also explored several demographic as well as co-morbid risk factors, but there were no statistically significant correlations between HA-MRSA isolates and the risk factors. Specifically, there was no correlation between HA-MRSA isolates and underlying risk factors like diabetes, hypertension, skin/soft tissue infections, skin ulcers/wounds, recent exposure to antibiotics, or hospital visits, etc. ($p > 0.05$, Chi-square test).

Conclusions

The prevalence of asymptomatic nasal carriage of HA-MRSA was higher than noted in several previous studies involving medical and pre-clinical students. Prevalence of nasal HA-MRSA carriage in health care providers was 15.1% in contrast to cell phone carriage of 9.0%. Cell phones carriage of HA-MRSA was significantly low in the hospital setting. This is definitely a good sign; however there is a need to reinforce an awareness campaign in the health care providers, especially medical students to take adequate care and precautions regarding the universal techniques of hand washing and hygiene thereby minimizing the risk of transmitting HA-MRSA and contamination of inanimate objects like cell phones. Although no risk factors were significantly associated with this high prevalence, it is prudent that universal measures of hand washing, personal sanitation and hygiene needs attention, especially in the two medical student group cohorts of this study.

Conflict of interest

The authors have no conflict of interest to disclose.

Ethical approval

The study was approved by the Institutional Medical Research and Ethics Committee, Oman Medical College, Bowsher, Azaiba, Sultanate of Oman.

Acknowledgements

The authors wish to thank Dean, Oman Medical College for providing necessary research facilities. This work was supported by a FURAP grant in August 2013 from the 'The Research Council' [TRC] of the Sultanate of Oman (Grant No. FRP/OMC/13/001).

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